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ON THE COAGULATION OF HEVEA LATEX AND A NEW METHOD OF COAGULATION.

By B. J. Eaton and J. Grantham.

In a paper communicated to the Congress of Applied Chemistry 1912 Whitby brought forward a theory that the natural coagulation of Hevea Latex was brought about by a coagulating enzyme. He showed that his theoretic enzyme was distinct from the oxidising enzyme known to be present in Hevea latex. His argument rested chiefly on the observation that latex can be prevented from coagulating, within the usual time, by heating, and that only after *3 or 4 days* does coagulation, accompanied by putrefaction, occur again. Whitby concludes that this excludes bacterial action since natural coagulation occurs within a few hours after tapping and bacterial infection must have taken place subsequent to the latex leaving the tree. The argument is open to the objection that the heating to which Whitby subjected his latex may have created conditions suitable for non-coagulating bacteria at the expense of the coagulating species. To take a well known example, ordinary untreated milk becomes sour and clots or coagulates owing to the action of the lactic acid bacteria, but sterilised milk, if allowed to become infected, first putrefies without coagulation. But one would not argue from this that the souring and clotting of milk was not due to bacteria.

Our experiments will be seen to favour a bacterial theory of natural coagulation.

In another part of his paper Whitby states that coagulation takes place *as well* in closed vessels as in open. As is now well known coagulation takes place *much better* in closed vessels and

Whitby himself mentions that in sealed vessels, which had been kept for some time, complete coagulation had occurred without decomposition. If Hevea latex be allowed to stand in open vessels, the amount of coagulation depends on the shape of the vessel and the depth of the latex. A thin layer of latex does not coagulate, but changes to a peculiar slime with a yellow surface scum. If latex be placed in tall cylinders coagulation is much more complete and the slime formation is much less, constituting only a small depth of the latex near the surface. The surface scum is also found to be alkaline in character and the serum below acid, showing two distinct processes of decomposition. This is the basis of the so-called "anaerobic" process of coagulation for which a patent has been taken out by Maude, Crosse, Pratt and Barrowcliff in the Federated Malay States. This process may thus be explained by a bacterial theory. The conditions are such as to inhibit a large number of bacterial species, including most of the putrefactive ones, while other species, including the coagulating ones, free from the competition of purely aerobic species, are encouraged. To find an explanation on the enzymic hypothesis is more difficult. We have since found that coagulation under these conditions is variable, on some days the coagulation being complete and on other days not quite complete, indicating a variable factor in the latex itself.

Experimental.

Experiment 1.

Three flasks plugged with cotton wool, containing fresh latex, were (in about 1-2 minutes) rapidly heated to 140°C-150°C in a steam autoclave, and slowly cooled. This presumably completely sterilised the latex. A slight amount of coagulation occurred, but the bulk of the latex was still liquid. One flask (A) was opened, another (B) had a little fresh latex placed in it and was then replugged, and the remaining one (C) was left untouched. Twenty four hours later the latex in flasks A and B was nearly completely coagulated and a yellow scum was forming on the surface the latex in flask C was unchanged and has remained so. The flasks A and B gradually developed all the characteristic putrefactive changes. In both these cases coagulation apparently runs parallel with putrefaction.

Experiment 2.

Three similar flasks containing latex were taken and heated in the autoclave at 90° to 100°C. Two (D and E) were left untouched and the third (F) was inoculated with a little fresh latex.

On the day following, partial coagulation had taken place in all three flasks. In D and E there was no trace of putrefactive change. D was opened and the serum was found to be slightly acid and sweet smelling. In F a yellow scum had formed and putrefactive changes had begun. One day later E and F were completely coagulated but the putrefaction of F was more pronounced than that of E. A day later E began to develop a yellow scum and show signs of putrefaction.

In both experiments there were control flasks, which were not sterilised, in which the latex coagultaed almost completely in the first 24 hours, formed a yellow surface scum and began to putrify.

These experiments have been repeated several times with similar results.

Both the latex heated to 150°C and to 100°C are afterwards readily coagulable by acetic acid.

It will be seen that the results in Experiment 1. agree with Whitby's, except perhaps that putrefaction was slightly more rapid. The rapidity varies greatly however in different experiments.

Now to what cause was the coagulation occurring in D and E in Experiment 2 due? Evidently not to the putrefactive changes, since these occurred subsequent to coagulation. Neither could they be due to any coagulating enzyme owing to the initial heating at 90°-100°C.

There remain two explanations (1) that it is due to a chemical or physical change produced by the heating, or (2) to a non-putrefactive bacterial change, the bacteria developing from the spores not killed by the heating to 100°C. The first is improbable owing to the time taken to coagulate and to the fact that the latex heated to 150°C and kept free from bacterial infection, did not coagulate.

There is of course nothing in these experiments to indicate the cause of natural coagulation since the initial heating may have rendered this cause inoperative. Nevertheless there is a close parallel in the changes taking place in the unsterilised latex and latex sterilised and then exposed to infection. The changes are however much slower in the latter case.

The experiments did seem to indicate however that coagulation by non-putrefactive bacterial action was a possibility. Now in a medium such as latex, containing protein material and lacking carbohydrates, the predominant bacterial changes are putrefactive, in which protein is decomposed with the formation of various malodorous substances such as skatol and indol.

In order to eliminate to some extent this predominance of putrefactive changes and encourage the non-putrefactive ones, cane sugar and glucose were added to latex and it was found with each of these that complete coagulation was obtained, and putrefactive changes were inhibited.

Experiment 3.

In the first experiments, the coagulations were carried out with pure crystalline dextrose and it was found that as small a quantity as 0·2 per cent of dextrose calculated on the latex (the latex contained from 25 to 30 per cent of dry rubber) was sufficient to bring about complete coagulation within 18 hours. The coagulation was also found to take place more readily in closed vessels, completely filled with latex. When the coagulation was carried out in closed vessels the clear serum was found to be acid. If the coagulation was carried out in open vessels complete coagulation also occurred, but a yellow slimy surface scum was produced which was alkaline to litmus, although the clear serum below the coagulum was acid. In both cases, using only a small quantity of dextrose, it was found that the sugar was completely decomposed, no dextrose remaining in the serum. The coagulum was full of gas bubbles and it was proved that the gas formed consisted chiefly of carbon dioxide. Similar results were obtained with the following sugars, cane sugar, lactose, arabinose, mannose and levulose.

The coagulum in each case possessed a sweet odour and the usual putrefactive changes had not taken place. Subsequent experiments with a less pure non-crystalline syrupy glucose (dextrose) gave similar results, complete coagulation being obtained with as small a quantity as 0·1 per cent calculated on the latex.

Experiment 4.

Subsequent experiments were carried out with the addition of dextrose to latex and it was found that if the temperature was kept low (below about 40-50°Fah.) coagulation was inhibited during 24 hours; after allowing the latex plus dextrose to stand again at ordinary atmospheric temperature (about 84°Fah) coagulation was complete and perfect during the subsequent 24 hours, the coagulum being sweet and free from putrefactive changes.

Further experiments were carried out with latex sterilised by various antiseptics and by heat and it was found that coagulation under the above conditions either did not take place or was delayed.

SUMMARY.

1. These experiments indicate a possible explanation of the

natural coagulation of the latex of Hevea brasiliensis viz. that it is due to certain bacteria which infect the latex after collection.

2. That there are two distinct types of organisms, one favoured by aerobic conditions which tends to inhibit coagulation and produces an alkaline slime in the presence of air and the other favoured by anaerobic conditions which effects the coagulation of the latex.

3. The coagulation of latex under anaerobic conditions is not constant; on some days complete coagulation occurring and on other days being much less complete, possibly due to a variation in the constituents of the latex.

4. By the addition of various sugars, coagulation under both aerobic and anaerobic conditions always occurs and is caused, in our opinion, by the fact that a medium is formed more favourable for the organisms which produce coagulation and less favourable to those producing putrefactive changes.

PRELIMINARY NOTE ON A NEW RAPIDLY VULCANISING RUBBER.

By B. J. Eaton.

In connection with the effect of different chemicals on the variability of plantation Para rubber in respect to behaviour on vulcanisation and rate of cure, it has been shewn in a previous number of the Agricultural Bulletin (Vol. No. III Nos. 6-7 March —April 1915) that an excess of acetic acid retards the rate of cure. As it is considered that this effect is due possibly to the action of the excess of acid on biological grounds, a strongly acid solution inhibiting the action of micro-organisms which are thought to produce the substance accelerating the rate of vulcanisation, experiments were carried out with various alkaline solutions, caustic soda (sodium hydrate), sodium carbonate and lime water in order to neutralise the acetic acid left in the rubber and to produce an alkaline medium which might be more favourable to the biological process considered responsible for the changes.

Experimental.

In these experiments the rubber used was "slab" rubber, *i.e.* pan coagulum lightly pressed, the slabs being about one inch thick. The latex diluted to contain 1½ lbs. of dry rubber per gallon was coagulated in the ordinary enamel coagulating pans by means of 3 ozs. of a 5% solution of acetic acid per gallon. On the day

following coagulation, the coagulum in each case was pressed to the same extent. Slabs were then soaked in solutions of (*a*) 1 per cent caustic soda, (*b*) 1 per cent sodium carbonate and (*c*) saturated lime water overnight *i.e.* for 18-24 hours. Controls were prepared for comparison. The slabs were then removed from the solutions and left on racks for about ten days, after which they were converted to thin crepe and dried.

Vulcanisation results:—The samples were vulcanised under the usual conditions, *i.e.* 90 parts of rubber to 10 parts of sulphur, for varying periods at 140°C. As the remarkably rapid rate of cure of the samples treated with caustic soda and sodium carbonate was not anticipated, they were at first cured at times which proved to be much too long and were consequently very overcured and brittle.

The following are the results obtained in the case of the samples soaked in caustic soda and sodium carbonate solutions together with the controls. The sample soaked in lime water did not cure more rapidly, being slightly slower than the control and is omitted here. (Table I).

Although only one experiment is given here, the experiment has been repeated a number of times with identical results.

The samples are as follows:—

142 Series i E. Sample of slab soaked in 1 per cent caustic soda solution.

142 Series i F. Sample of slab soaked in 1 per cent sodium carbonate solution.

142 Series i H. Control sample.

TABLE I.

Ref No	Optimum time of cure. Hours	Breaking load. Kgs. per sq. mm. (A)	Elongation at break. (orig. length=100) (B)	Product (A x B)
142 Series i E.	½ hour.	1·43	940	1374
142 „ i F.	¾ „	1·44	970	1396
142 „ i H.	1¼-1½	1·51	966	1458

Remarks:—As will be seen the effect of caustic soda solution is to reduce the time of cure under the above conditions to ½ hour or possibly less. The effect of the sodium carbonate solution is less than that of the caustic soda but is quite marked over the control. It is possible that solutions of different strengths will give different results and further experiments will be carried out. These experiments, like all of our more recent experiments are carried out on "slab" rubbers *i.e.* lightly pressed coagulum, since this

type of rubber is far more sensitive to any change than ordinary sheet or crepe, as the differences are exaggerated. The experiment however will be repeated with sheet and crepe, since the rate of cure of these types should be increased though not to the same extent as slab. Samples will also be left in slab form for a shorter period than 10 days, as it is possible that the change in the rubber may be brought about more rapidly than in the case of ordinary untreated slab which requires about six days to produce the amount of substance causing maximum acceleration in rate of cure.

Hitherto no slab rubber has cured in less than 1-1¼ hours. The physical or mechanical properties of these rapidly curing samples are also excellent, as is seen by the figures.

Whether the effect produced by these alkalis is a direct chemical one or due to the formation of an alkaline medium more favourable to biological processes remains to be seen.

In order to show how absolutely overcured these samples become if cured for any longer period the following table is included:—

TABLE II.

Ref. No.	Time of cure.	Breaking load. (Kgs. per sq. mm.) A	Elongation at break. (orig. length 100) (B)	Product (A x B)
142 Series i E.	½ hour.	1·43	940	1374
	¾ „	1·09	821	894
	1 „	0·21	443	93
	1¼ „	0·16	347	55
142 Series i F.	½ „	1·27	1007	1278
	¾ „	1·44	970	1396
	1 „	1·42	931	1322
	1¼ „	1·02	809	825
	1½ „	0·19	433	82
142 Series i H.	1 „	1·21	1035	1252
	1¼ „	1·51	1011	1526
	1½ „	1·51	966	1458
	1¾ „	0·29	595	172

As will be seen from the above table, sample E (caustic soda treatment) is absolutely overcured at 1 hour, and sample F at 1½ hours while sample H does not become badly overcured under 1¾ hours.

The load-stretch curves are even more instructive than the figures given above.

It is possible that a rubber of this type may be of considerable value commercially in view of the remarkably rapid rate at which it vulcanises.

METHODS AND MATERIALS FOR THE CONTROL OF INSECT PESTS.

By P. B. Richards.

Part VIII.

Chemical Measures. III. Fumigants.

The application of fumes for the discouragement of insect attack is, next to hand-picking, probably the most ancient of all methods for dealing with insect pests. The distaste of mosquitoes for "smudges" has long been known and turned to account by the Chinese and Japanese, while advantage has been taken in many countries of the fact that thick smoke drives away many insects from growing crops; so much so that it has often become a matter of regular agricultural practice to light fires at critical periods in the growth of the crops, creating a dense pall of smoke on the fields which prevents the immigration of some insects and drives out others, keeping the plant clear until the danger is past.

While smoking from fires is a method to be encouraged for special attacks over dense crops under suitable weather conditions, —it is obvious that in windy weather smoking would be futile— it acts only as a deterrent and does not kill the insects. Modern fumigation methods, on the contrary, aim at the destruction of the pest.

The suffocation of insects by generating poisonous gases is only possible when the attacked objects can be treated in an enclosed space. The method is of greatest economic importance in its employment to get rid of those particular pests which are capable of doing such enormous damage to stored foodstuff, seeds, and manufactured articles. It is also largely and successfully employed for the treatment of scale insects and mealy bug on fruit trees, for killing injurious insects and other organisms in the soil, for ridding houses of noxious insects, and for the destruction of termites.

The two fumigants most commonly employed are hydrocyanic acid gas and carbon-bi-sulphide. Sulphur dioxide, carbon dioxide, and nicotine are also used.

Hydrocyanic Acid Gas.

Preparation. Hydrocyanic acid gas is evolved when sulphuric acid and potassium cyanide are brought together. The usual proportions are one part of potassium cyanide and two parts of concentrated sulphuric acid, with four parts of water. On account of the highly poisonous nature of potassium cyanide and the evolved gas, and of the strong corrosive action of sulphuric acid, great care must be taken in all steps of the preparation.

Having determined the cubic capacity of the space to be fumigated and the strength at which the gas is to be used, the requisite amount of potassium cyanide is weighed out into convenient quantities in paper bags or packets of not more than two pounds each. The corresponding quantities of sulphuric acid and water are measured out and mixed in an earthenware or glass vessel by pouring the acid slowly and carefully into the water. Metal vessels must not be used; neither must the water be poured into the acid or its corrosive effect will be painfully demonstrated upon the operator. To prevent possibility of damage to floors, woodwork or plants should the acid boil over or spill on mixing with water, it is best to do the mixing out of doors.

Place all the receptacles containing the acid in position with the bags of potassium cyanide alongside, then, starting at the far end away from the exit, gently but quickly place each bag of cyanide in its crock of acid, and get outside as quickly as possible, closing up the exit immediately. The time taken by the acid to penetrate the paper bag allows a few seconds for the operator's retreat before the poisonous gas is evolved. A convenient and safe way of introducing the cyanide into the acid is to suspend the bag over the receptacle by a string which is led through a hole in the door or wall of the fumigating chamber. The operator can then retire and seal up the door, afterwards lowering the bag into the acid.

Properties.

Hydrocyanic acid gas is a colourless, volatile gas, soluble in water, possessing a faint odour of almonds, and extremely poisonous. In the liquid state as Prussic Acid, its poisoning power is known universally. Breathing a small quantity of dilute gas induces a violent headache, while one breath of the pure gas is fatal. It is therefore a fumigant to be employed with great care. Hydrocyanic acid gas exterminates all animals which breathe a sufficient quantity. When properly used for fumigating a building, tent or fumigating chamber, all contained vermin, rats, mice, lizards, cock-

roaches, flies, fleas and the like which live in the open will be killed. It is important to note, however, that hydrocyanic acid gas is effective only where it penetrates easily. It is therefore no good for fumigating insects living in small holes and crevices, or for grain and soil treatment.

Uses.

(*a*) For fumigating fruit trees attacked by scale insects, mealy bugs, etc.

This treatment is applied largely in countries where fruit growing is of considerable economic importance. It is not likely to be employed in Malaya in the near future. The trees to be treated are covered with a specially designed tent inside which the gas is generated.

(*b*) For fumigating nursery stock before transport, and for the treatment of imported plants.

To each 100 feet of cubic space.

1 oz. of 98% potassium cyanide.
or 2¼ oz. of 45% potassium cyanide.
2 oz. of sulphuric acid.
4 oz. water.

The stock is placed in a fumigating chamber with a close fitting door. The gas is generated by the method described above, the door closed and sealed if necessary with paper, the plants being fumigated for from 30 to 40 minutes. The chamber is then opened and allowed to air for an hour before the plants are removed. All caterpillars, scale insects, plant lice, and the eggs of most insects are killed by this treatment which is the best yet devised for the control of distribution of pests by the agency of man.

(*c*) For fumigating growing green plants in greenhouse, fumigating chamber, &c.

The high temperature of the tropics renders this operation more risky here than in the temperate zones.

The fumigation should be done at night. The foliage must be dry. It is not possible to say in advance what quantity of material will be required. Trials with, say, ½ oz to 1 oz. of cyanide in 1000 cubic feet should be made, increasing the dose subsequently if the insects are not killed and the plants remain uninjured.

The fumigation of green plants with hydrocyanic acid gas is especially valuable against mealy bugs and aphids. It is useless against most scale insects as the gas is not employed at sufficient strength to effect them.

(*d*) For fumigating houses, stores, mills &c.

Determine the cubic space to be fumigated and use one ounce of 98% Potassium cyanide or two and a quarter ounces of 45% purity, one ounce of Sulphuric acid, and three ounces of water to each hundred cubic feet of air space. The materials are measured out and prepared as previously described, and placed in readiness in the rooms to be treated. All doors except those required for exit are closed, as are windows and ventilators, and any apertures should be made as nearly as possible airtight by pasting over with paper. Starting from the far end upstairs, the operator places each packet of cyanide into its pot, and immediately leaves that room for the next, thus working down to the ground floor and out by the exit as quickly as possible, closing and sealing the door behind him. If there are many generators to be attended to, two or more operators should work in concert.

The fumigant should be allowed to act for twenty four hours. The doors and windows should then be opened from the outside as far as possible. After an hour or more the building may have ventilated sufficiently to permit of entry, but no attempt should be made to enter if any smell of the gas persists. Permanent occupation of the building should be preceded by at least twelve hours thorough airing.

If due precautions are not taken, fumigation with hydrocyanic acid gas may be fraught with disaster to the operators. In competent hands, however, it is quite safe, and is one of the most useful of insecticides.

Carbon-bisulphide.

Fumigation by carbon-bisulphide is accomplished by injecting into or pouring round the objects requiring treatment the requisite quantity of liquid carbon-bisulphide.

Properties.

Carbon-bisulphide is an oily colourless liquid which possesses a pleasant smell when pure, but the commercial product usually smells like rotten eggs and is yellow on account of contained impurities. It is very volatile, vapourising with extreme rapidity in the open at ordinary temperatures. It should be stored in stoppered casks or jars—not corked bottles—and to prevent loss by evaporation a small quantity of water may be run in. As the liquid is heavier than water and is only very slightly soluble, the water forms a protective layer over the top of the carbon-bisulphide.

As a liquid it is highly imflammable, while the vapour when mixed with air explodes violently on iguition. The ignition point

is very low. No fire of any sort, or even any hot body the temperature of which is above the boiling point of water, 212°F., should therefore be allowed in or near a store of Carbon-bisulphide or the place where fumigation is in progress. In treating a building supplied with electricity, the current should be cut off before fumigation commences. Carbon-bisulphide should be stored in a cool place, and should not be exposed to the sun.

Liquid carbon-bisulphide in considerable quantity is poisonous to man. Inhalation of the gas produces violent headache and nausea and is to be avoided, but is not dangerous in the same degree as hydrocyanic acid gas. The main danger in its use is from fire.

Insects subjected to the action of carbon-bisulphide vapour are at first anaesthetised and later asphyxiated. The action is slow, taking many hours to ensure death unless the atmosphere is very heavily charged with the vapour.

Carbon-bisulphide vapour is readily diffused, getting thoroughly into all holes and crevices. It is therefore, notwithstanding its lower toxicity, a better fumigant than hydrocyanic acid gas for treating seed, cereals, pulses, and other foodstuffs, and close packed manufactured articles. The vapour is heavier than air so should be applied from above downwards.

Uses.

(*a*) Seeds and foodstuffs stored for any length of time, especially in hot climates, are very susceptible to insect attack, which may be so serious as to render the stock valueless either for food or for planting. To mention a few which occur in Malaya, stored rice is attacked by the Rice Weevil, *Calandra oryzae,* and by the caterpillars of a small grey Tineid moth, *Sitotroga cerealella.* Wheat, flour, grain, and similar foodstuffs are often heavily infested with small Pyralid moths of the genus *Ephestia* the caterpillars of which may be found in matted galleries of silk running throughout the food. Flour and biscuits also are attacked by a small red Tenebrionid beetle, *Tribolium sp.,* which spoils provisions by giving them a very repulsive taste. Dried peas and beans are attacked by several species of Bruchid beetles, sometimes to the total destruction of the stock. Annoyance is often caused to smokers by the cheroot beetle, *Lasioderma serricorne*, which infests stored tobacco, the larvae feeding here and there throughout the body of the cheroot, and the adult making small round holes in the wrapper for emergence. The loss to the tobacco manufacturer from the beetles boring through bales of cigar wrappers of good quality, thus rendering them unfit for use, is often enormous.

These are but a few of the cases which might be cited of insect attack upon stored vegetable matter. Owing to the smallness of the stocks in any one place these pests have not compelled the attention here which has had to be given them in the larger grain producing countries where enormous stores of grain are held for considerable periods. Nevertheless, the average loss in Malaya must reach a considerable sum. It is estimated that in India the Rice Weevil alone "at a moderate estimate may be said to destroy five per cent of all stored grain which is kept for more than a couple of months after harvest." The methods applied on a large scale for big stocks of grain elsewhere are equally applicable for warehouses, kedais, and private stocks here, and if practised would amply repay the outlay in labour and materials.

There is no known method for treating stored vegetable produce in general which renders it permanently immune to insect attack if exposed, and which does not at the same time unfit it for food or for germination. The only sure preventive is to store in insect proof bins, jars, or tins after getting rid of any infection. It is to get rid of the insects harboured at the moment that fumigation with Carbon-bisulphide is employed. Reinfection may take place quickly if the fumigated material is not at once stored in an insect proof place. Should this not be feasible, repeated fumigations may be necessary in order to prevent the pests from reaching enormously destructive proportions.

For the treatment of grain one pound of carbon-bisulphide is allowed to each hundred bushels. In treating large quantities, some of the liquid is introduced through a pipe into the middle of the heap and the remainder poured on top. To keep the pipe clear when pushing it into the heap, a stick is loosely fitted into the pipe and withdrawn leaving the pipe in position. For smaller quantities, the material to be treated is placed in a barrel or bin that can be made fairly airtight—the less leakage, of course, the better—and the requisite quantity of carbon-bisulphide either placed in shallow dishes on the top of the material or, if grain, poured directly on to the material. The cover is at once put on, and left for twenty-four hours, after which the bin is opened and allowed to air, and the material after airing at once stored in insect proof receptacles. If storing is delayed for a day reinfection may have taken place.

The quantity of carbon-bisulphide required for fumigating small quantities of material may be taken as one ounce to fifty gantangs if the chamber is full of grain, or the same quantity to

fifteen cubic feet of space if other materials are being treated. For small vessels or boxes, allow one teaspoonful to each cubic foot of space.

A useful form of fumigating chamber consists of an airtight wooden box the cover of which is provided with a flange which fits into a gutter all round the outside of the box. The gutter is filled with water, and when the lid is put on, the flange dips into the water, making an airtight fitting. This type of chamber is not available for hydrocyanic acid gas fumigation as this gas is soluble in water.

In the absence of an airtight box, heavy cloths thrown over the top assist in retaining the fumes.

(*b*) Soil fumigation.

Many injurious animals such as cockchafer grubs, wireworms, root aphids and eelworms, living below the surface of the ground and feeding upon the roots of plants are controlled by injecting carbon-bisulphide into the soil close to the affected plant. Care should be taken not to allow the fluid carbon-bisulphide to come into contact with the roots, or the plant may be badly injured. No trouble should however arise from contact of the roots with carbon-bisulphide vapour, except perhaps a temporary set back which is more than compensated for by the subsequent increase in vigour of the plant.

Carbon-bisulphide is best injected into the soil by means of a special injecting pump which regulates the dose and the depth at which it is applied. In the absence of such apparatus, a hole to the required depth may be made with a rod, the dose of liquid poured in, and the hole at once stopped with earth.

The individual doses vary from a quarter of an ounce to four ounces, and the depth at which applied may be from six to twenty four inches according to the nature of the soil and the conditions of attack. No fixed rules can be laid down to meet all cases, and planters who contemplate using carbon-bisulphide for soil injection are recommended first to communicate with the Agricultural Department.

(*c*) Treatment of large boring beetles in fruit trees, rubber trees &c.

Clean up the mouth of the burrow with a sharp knife, or with a small auger. Inject about a teaspoonful of carbon-bisulphide into the hole and plug up the hole with a tight fitting cork or with clay. An ordinary oiling can makes an effective injector.*

*Bainbridge Fletcher recommends for boring beetles the injection of a mixture of two parts chloroform and one part creosote. This mixture has the advantage over carbon-bisulphide of acting as a preservative to the wood.

On the other hand it is more expensive. See "Some South Indian Insects" p. 133.

Sulphur Dioxide.

Sulphur dioxide is prepared by burning sulphur in air. For purposes of fumigation the sulphur is placed in a shallow open vessel which in turn, as a precaution against fire, is placed in a larger vessel containing sand and earth. Two pounds of sulphur are buried for each thousand cubic feet of airspace.

Properties.

Sulphur dioxide is a colourless gas, with a characteristic suffocating smell which produces a sensation of choking. It is not inflammable. The gas is soluble in water in combination with which it pours Sulphurous acid.

Sulphus dioxide gas is poisonous to insects but it is also directly harmful to vegetation. Leaves are "scorched" by a weak mixture of the gas in air, while at greater strengths buds and young shoots are killed. The fumes also destroy the germinating power of seeds and have considerable bleaching effect on fabrics.

Use.

It is obvious from a consideration of the above properties that sulphur dioxide is not applicable, to plant fumigation. Its major use is for killing bedbugs and such like vermin in empty rooms and for this purpose it is excellent, being cheap, effective, and easy to employ. The sulphur is ignited and the room at once closed. The fumes should be allowed to act for 24 hours.

Carbon Dioxide.

Carbon dioxide can be readily prepared by treating limestone or marble with hydrochloric acid. The gas is, however, universally used for the preparation of mineral waters for which purpose it it put up in liquid form in steel bottles, and it would probably be more convenient to obtain these than to prepare the gas on a small scale for oneself.

Properties.

Carbon dioxide is a heavy colourless gas which is incapable of supporting combustion or respiration. Asphyxiation results from breathing the pure gas, while an atmosphere containing upwards of 10 per cent of Carbon dioxide produces an effect on animals similar to narcotic poisoning. Plants, and particularly seeds are able to withstand for a considerable period an excess of carbon dioxide which is quickly fatal to insects. Sufficient work has not yet been done on the subject to warrant any broad generalisations, but there can be no doubt of the utility of the gas in the treatment

of delicate plants and in the disinfection and storing of valuable seed. It is, however, in connection with valuable dried products such as spices and tobacco that carbon dioxide is likeliest to appeal to Eastern cultivators. Hydrocyanic acid gas and carbon bisulphide cannot be unreservedly recommended for the fumigation of such products on account of the danger of impairing their quality. No such result will be feared if carbon dioxide is used, provided that the material for treatment is dry. In particular should this method be applied to all cigars, cigar wrappers, cigarettes and other valuable tobacco before storing and again before packing as a precaution against the attack of the cheroot beetle.

Nicotine Tobacco.

Fumigation with tobacco is only of service in the treatment of plant lice and such small insects attacking greenhouse plants and small pot plants. The fumes are obtained by burning tobacco stems and dust, or by evaporating aqueous solutions of nicotine in a shallow pan. The plants to be fumigated may be placed in a fairly airtight box and the fumes led in from the generator through the bottom of the box by means of a pipe.

Sun Drying.

One should apologise for the inclusion of such a foreign subject in a chapter on Fumigants, but as the treatment of stored grain is one of the most important matters considered under that heading this is perhaps the best moment to discuss the use of the sun as an insecticide.

All insects require a certain amount of moisture in their surroundings and their food to enable them to live. This percentage varies according to the habit of the insect. Less is required by grain feeding insects than by most others, but even they cannot live in thoroughly dried grain. The object of sun drying is to reduce the moisture content of the attacked food beyond the minimum necessary to support the life of the particular pest.

Calandra oryzae, the rice weevil, which yearly destroys large quantities of stored rice in Malaya is one of the pests which is amenable to this method of treatment. Bainbridge Fletcher* writing of this pest in India says:—"It has been found by experiment that a certain minimum (about 8 per cent) of moisture in their surroundings is necessary to the successful existance and breeding of these weevils, so that, if grain can be well dried in the sun to reduce its moisture content as much as possible and then stored

* Some South Indian Insects, p. 161.

in insect proof receptacles in a dry place it will be as secure from attack as is possible under practical conditions. In districts where paddy is stored in jars there should be little difficulty in having the grain sun dried before storage and then fastening up the jars so as to exclude weevils; for jars, not in use, an earthenware cap, luted on with clay, might be used, and those in daily use could be covered simply with a fine cloth tied around the neck of the jar. Care should of course be taken that the jars are thoroughly cleaned out and free from weevil or old infected grain before filling them afresh and also that all fastenings are sufficiently tight to be weevil proof."

Sitotroga cerealella, a small moth which is another important pest of stored rice, the pulse beetles which destroy stored peas and beans, and other small insects of similar habit may be kept in check by sun drying. It is *par excellence* the method for kedai keepers and raiots who have comparatively small quantities of such material to handle. Any dry place will serve to spread out the grain, but flat adobe or cement roofs would be ideal. Large stocks, however, cannot be conveniently handled, and when such require treatment carbon bisulphide should be employed.

THE THINNING OUT OF RUBBER TREES.

By B. Bunting.

(*This paper was prepared and translated into Romanised Malay for the benefit of Small-holders, and printed copies have been circulated through the District Officers*).

The problem of thinning out of rubber trees is undoubtedly one of the most important affecting small holdings in the Malay Peninsula.

When rubber was first planted in this country, trees were planted very close together, the common distances of planting being 10 ft. × 10 ft., 12 ft. × 12 ft., and 14 ft. × 14ft., but experience has proved that all these were much too close and most of the large estates with closely planted areas are beginning to thin out these overcrowded areas and reduce the total number of trees to about 100 per acre.

In planting up new areas nothing less than 20 ft. × 20 ft., or 108 trees per acre, should be attempted, and time will probably

show that a better distance is 25 ft. × 25 ft., which only gives 70 trees per acre.

Effects of Close Planting.

Trees which are closely planted have only a small leaf area and are much more liable to attacks of disease. When tapping commences they are still further weakened and therefore give a very poor renewal of bark, which is so thin that it is not possible to tap the trees without wounding after the original bark has been consumed.

Advantages of Thinning Out.

The benefits obtained from thinning out are that the trees are much healthier, yield more rubber, and renew their bark quicker. There is also a great saving in labour and it has been found that after thinning out the trees may yield double the amount of rubber, so that if the yield per tree is doubled from 1½ lbs. to 3lbs. the cost of collecting will be reduced by half, as each coolie will bring in double the amount of latex.

Another important point is that if the yield per tree is doubled the percentage of first quality rubber is considerably increased, as less scrap rubber will be obtained when only half the number of trees are being tapped. Again, if the number of trees is reduced there will be a large saving on tapping tools, as a less number of cups and spouts will be required to bring in the same amount of latex.

As an example we may take a holding of say 6 acres planted with rubber 14 ft. x 14 ft., giving 222 trees per acre with a total of 1332 trees, requiring 4 tappers to collect a yield of 1998 lbs. per annum at a cost of 22 cts. per lb., whilst the same area after thinning out would contain 111 trees per acre requiring only 2 tappers to collect a similar yield at the reduced cost of 11 cts. per lb.; besides this there would be a saving of 666 cups and spouts.

We may say that by thinning out, fewer coolies are required to produce each pound of rubber, fewer cups and spouts are used, less low grade rubber is produced and expenses are considerably reduced in many directions.

Method of Thinning Out.

The best method of thinning out is by selection and should commence by removing all the small, weakly trees, which are very backward in appearance as these are sure to be very poor yielders owing to their stunted growth. Next remove all trees which have

a very irregular growth such as bad trunks and forked branches, which are liable to be split by winds. After these have been exhausted it may be necessary to cut out a number of good trees in order to improve the spacing of those which remain.

If the trees in the area to be thinned out have not reached the tapping stage they should be reduced to 100 trees per acre immediately, but if they are producing it should be carried out gradually at intervals of say 6 months, so that any drop in yield will not be apparent.

The trees should be cut out straight away and the roots extracted and burnt so that there is little chance of disease attacking the dead stumps.

In some cases the stumps are tapped to death but the yield of rubber is so small that it is not a profitable operation and, especially at the present price of rubber, barely covers the cost of tapping and collecting.

It should be pointed out that if the area to be thinned is in bearing there will be a drop in the yield immediately after thinning out is commenced, but this will only be temporary, and after a period of 6 to 12 months the yield per tree will increase and make up for the trees which have been removed. Another point is that if the trees are small any thinning out may reduce the shade and consequently the growth of weeds may be encouraged, this again is only a temporary matter and not of great importance where only small areas are concerned.

With trees very closely planted the yields fall rapidly when tapping renewed bark is commenced and close planting may have shown good profits with rubber at $2-3 per lb. but now the price is as low as $1 per lb. the margin of profit is very small and the maximum yield per tree must be obtained to keep down the expense of collecting.

The longer thinning out is delayed the more difficult will be the work, the longer will the remaining trees take to increase their yields, and the lower will be the ultimate profits per acre.

Exports of Rubber from British Malaya (other than the F. M. S.)

State	Month	Quantity
Johore	September 1915	lbs. 5,618,516
Kelantan	September 1915	lbs. 130,848
Kedah		
Perlis	September 1915	lbs. 847
British North Borneo	September 1915	lbs. 202,800½
Brunei		

FEDERATED MALAY STATES.

Comparative Statement of Cultivated Rubber Exported, with Value and Duty Collected Thereon, During the Years 1915 and 1914.

Destination.	Exported during October, 1915.	Previously.	Total export during the year.	Export during similar period of previous year.	Increase.	Decrease.	Value of rubber exported, 1915.	Duty collected, 1915, to date.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	$	$ c.
Straits Settlements ...	2,959.96	20,437.69	23,397.65	14,398 43	8,999.22	...	41,921,068	
United Kingdom ..	1,117.72	9,613.01	10,730.73	8,556.48	2,174.25	...	21,272,305	
Continent of Europe...	...	8.00	8.00	807.78	...	799.78	15,880	
Ceylon	41.93	503.82	545.75	584.20	...	38.45	1,080,269	
Other Countries ...	...	95.07	95.07	100.27	...	5.20	181,447	
Total ...	4,119.61	30,657.59	34,777.20	24,447.16	11,173.47	843 43	64,470,969	1,785,585 80

KUALA LUMPUR,
6th November, 1915.

E. BURNSIDE,
Acting Commissioner, Trade and Customs, F.M.S.

Abstract of Meteorological Readings in the various Districts of Malaya for the month of October 1915.

DISTRICT.	Mean Barometrical Pressure at 32° Fah.	Maximum in Sun.	TEMPERATURE.				HYGROMETER.				Prevailing Direction of Winds.	Total Rainfall.	Greatest Rainfall during 24 hours.
			Mean Dry Bulb.	Maximum.	Minimum.	Range	Mean Wet Bulb.	Vapour Tension.	Dew Point.	Humidity.			
Kelantan, Kota Bahru ...	...	138.	82.3	90 74	74.32	16.42	77.5	.848	74.3	76.	...	11.73	1.58
Pahang, Kuala Lipis ...	...	...	81.3	90.3	73.4	16.9	76.5	...	...	...	...	4.57	1.27
Johore, Johore Bahru ...	...	...	...	88.05	74.03	14.02	...	...	...	...	...	11.42	...
Singapore, Kandang Kerbau	29.799	156.0	85.7	88.2	75 0	13.2	78.5	.892	...	77.	...	7.67	1.52
Malacca, Durian Daun ...	29.795	150.5	82.7	87.9	72.1	15.8	79.8	.977	...	88.	N.W.	12.00	3.34
Negri Sembilan, Seremban	...	146.5	80.6	88.4	72.1	16.3	76.6	.847	74.1	81.9	S.W.	11.56	2.64
,, Kuala Pilah ...	...	152.2	81.4	90.0	72.7	17.3	78.0	.864	74.8	83.7	S.W.	6.05	1.85
,, Port Dickson	...	123.1	82.6	88.2	74.5	13.7	77.3	.871	75.3	78.5	S.W.	17.88	6.35
Selangor, Kuala Lumpur ...	29.806	138.0	79.9	85.6	75.7	9.9	77.5	.897	75.9	87.	S.E.	6.66	1.09
,, Klang ...	...	...	81.7	86.5	74.6	11.9	76 8	...	...	...	...	6.49	2·53
,, Kuala Selangor ...	...	..	...	89.1	75.1	14 0	...	...	...	...	...	9.38	2.62
,, Rawang ...	...	...	...	92.1	...	...	...	...	...	...	...	4 31	1.50
Perak, Telok Anson ...	...	...	82.65	92.	71.	21.	78.32	.912	...	83.	...	7.47	3.55
,, Ipoh ...	...	...	82.42	95,	71.	24.	76.86	.849	74.59	77.	...	7.59	1.65
,, Taiping ...	...	159.	82.27	93.	73,	20.	77 03	.860	...	79.	...	10.91	2.73
,, The Cottage ...	...	...	..	...	..	...	...	...	...	...	...	27.46	6.95
,, Parit Buntar ...	...	...	82.93	93.	72.	21.	77.70	.881	...	79.	...	15.99	3,68
Penang, Georgetown ...	29.815	143.3	82.05	88.2	73.1	15.1	77.7	.887	74.6	80.3	...	14.93	4.26
Kedah, Alor Star ...	...	...	...	...	...	...	...	...	...	...	...	9.24	2.00
Perlis, Perlis ...	...	...	...	88.38	74.77	13.61	...	...	...	...	...	5.94	